

ECT305	ANALOG AND DIGITAL COMMUNICATION	CATEGORY	L	T	P	CREDIT
		PCC	3	1	0	4

Preamble: This course aims to develop analog and digital communication systems.

Prerequisite: ECT 204 Signals and Systems, MAT 204 Probability, Random Process and Numerical Methods

Course Outcomes: After the completion of the course the student will be able to

CO 1	Explain the existent analog communication systems.
CO 2	Apply the concepts of random processes to LTI systems.
CO 3	Apply waveform coding techniques in digital transmission.
CO 4	Apply GS procedure to develop digital receivers.
CO 5	Apply equalizer design to counteract ISI.
CO 6	Apply digital modulation techniques in signal transmission.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO 1	3	3										
CO 2	3	3	2	3	3							
CO 3	3	3	2	3	3	2						2
CO 4	3	3	2	3	3	2						2
CO 5	3	3	2	3	3	2						2
CO 6	3	3	2	3	3	2						2

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	10	10	20
Understand	30	30	60
Apply	10	10	20
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks
 Continuous Assessment Test (2 numbers) : 25 marks
 Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions**Course Outcome 1 (CO1): The existent analog communication system**

1. What are the needs for analog modulation
2. Give the mathematical model of FM signal and explain its spectrum.

Course Outcome 2 (CO2): Application of random processes

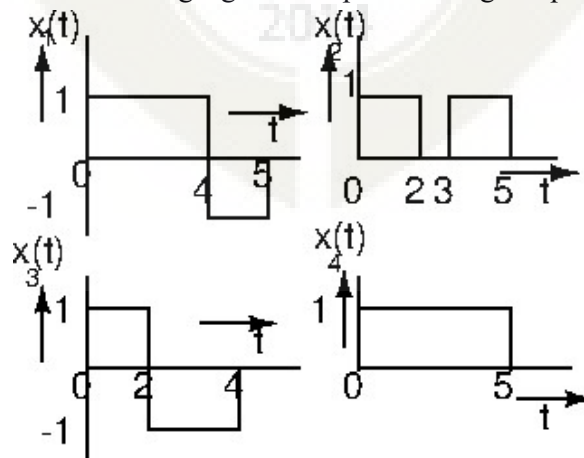
1. Compute the entropy of a Gaussian random variable.
2. A six faced die is thrown by a player. He gets Rs. 100 if face 6 turns up, loses Rs. 20 if face 3 or 4 turn up, gets Rs. 50 if face 5 turns up and loses Rs 10 if face 1 or 2 turn up. Draw the pdf and CDF for the random variable. Check if it is profitable based on statistical expectation.

Course Outcome 3 (CO3): Waveform coding

1. Compute the A and mu law quantized values of a signal that is normalized to 0.8 with $A=32$ and $\mu=255$.
2. Design a 3-tap linear predictor for speech signals with the autocorrelation vector $[0.95, 0.85, 0.7, 0.6]$, based on Wiener-Hopf equation. Compute the minimum mean square error.

Course Outcome 4 (CO4): G-S Procedure and effects in the channel

1. Apply G-S procedure on the following signals and plot their signal space.



2. Derive the Nyquist criterion for zero ISI.

Course Outcome 5 (CO5): Digital modulation

1. Give the mathematical model of a BPSK signal and plot its signal constellation.
2. Draw the BER-SNR plot for the BPSK system

SYLLABUS

Module 1 Analog Communication

Block diagram of a communication system. Need for analog modulation. Amplitude modulation. Equation and spectrum of AM signal. DSB-SC and SSB systems. Block diagram of SSB transmitter and receiver. Frequency and phase modulation. Narrow and wide band FM and their spectra. FM transmitter and receiver.

Module 2 Review of Random Variables and Random Processes

Review of random variables – both discrete and continuous. CDF and PDF, statistical averages. (Only definitions, computations and significance) Entropy, differential entropy. Differential entropy of a Gaussian RV. Conditional entropy, mutual information. Stochastic processes, Stationarity. Conditions for WSS and SSS. Autocorrelation and power spectral density. LTI systems with WSS as input.

Module 3 Source Coding

Source coding theorems I and II (Statements only). Waveform coding. Sampling and Quantization. Pulse code modulation, Transmitter and receiver. Companding. Practical 15 level A and mu-law companders. DPCM transmitter and receiver. Design of linear predictor. Wiener-Hopf equation. Delta modulation. Slope overload.

Module 4 G-S Procedure and Effects in the Channel

Gram-Schmitt procedure. Signal space. Baseband transmission through AWGN channel. Mathematical model of ISI. Nyquist criterion for zero ISI. Signal modeling for ISI, Raised cosine and Square-root raised cosine spectrum, Partial response signalling and duobinary coding. Equalization. Design of zero forcing equalizer. Vector model of AWGN channel. Matched filter and correlation receivers. MAP receiver, Maximum likelihood receiver and probability of error. Capacity of an AWGN channel (Expression only) -- significance in the design of communication schemes.

Module 5 Digital Modulation Schemes

Digital modulation schemes. Baseband BPSK system and the signal constellation. BPSK

transmitter and receiver. Base band QPSK system and Signal constellations. Plots of BER Vs SNR with analysis. QPSK transmitter and receiver. Quadrature amplitude modulation and signal constellation.

Text Books

1. "Communication Systems", Simon Haykin, Wiley.
2. "Digital Communications: Fundamentals and Applications", Sklar, Pearson.
3. "Digital Telephony", John C. Bellamy, Wiley

References

1. "Principles of Digital Communication," R. Gallager, Oxford University Press
2. "Digital Communication", John G Proakis, Wiley.

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	Analog Communication	
1.1	Block diagram of communication system, analog and digital systems , need for modulation	2
1.2	Amplitude modulation, model and spectrum and index of modulation	2
1.3	DSB-SC and SSB modulation. SSB transmitter and receiver	2
1.4	Frequency and phase modulation. Model of FM, spectrum of FM signal	2
2	Review of Random Variables	
2.1	Review of random variables, CDF and PDF, examples	2
2.2	Entropy of RV, Differential entropy of Gaussian RV, Expectation, conditional expectation, mutual information	4
2.3	Stochastic processes, Stationarity, WSS and SSS. Autocorrelation and power spectral density. Response of LTI systems to WSS	3
3	Source Coding	
3.1	Source coding theorems I and II	1
3.2	PCM, Transmitter and receiver, companding Practical A and mu law companders	4
3.3	DPCM, Linear predictor, Wiener Hopf equation	3
3.4	Delta modulator	1

4	GS Procedure and Channel Effects	
4.1	G-S procedure	3
4.2	ISI, Nyquist criterion, RS and SRC, PR signalling and duobinary coding	3
4.3	Equalization, design of zero forcing equalizer	3
4.4	Vector model of AWGN channel, Correlation receiver, matched filter	4
4.5	MAP receiver, ML receiver, probability of error	1
4.6	Channel capacity, capacity of Gaussian channel, Its significance in design of digital communication schemes	2
5	Digital Modulation	
5.1	Need of digital modulation in modern communication.	1
5.2	Baseband QPSK system, signal constellation. Effect of AWGN, probability of error (with derivation). BER-SNR curve, QPSK transmitter and receiver.	4
5.3	QAM system	1



Model Question Paper**A P J Abdul Kalam Technological University**

Fifth Semester B Tech Degree Examination Branch:

Electronics and Communication

COURSE: ECT 305 ANALOG AND DIGITAL COMMUNICATION**Time: 3 Hrs****Max. Marks: 100****PART A***Answer All Questions*

- 1 Explain the need for modulation (3)K2
- 2 Plot the spectrum of an FM signal (3)K2
- 3 In a game a six faced die is thrown. If 1 or 2 comes the player gets Rs 30, if 3 or 4 the player gets Rs 10, if 5 comes he loses Rs. 30 and in the event of 6 he loses Rs. 100. Plot the CDF and PDF of gain or loss (3)K3
- 4 Give the conditions for WSS (3)K2
- 5 Compute the step size for a delta modulator without slope overload if the input is $A \cos 2\pi 120t$ (3)K3
- 6 State source coding theorems I and II (3)K1
- 7 Give the Nyquist criterion for zero ISI. (3)K1
- 8 Give the mathematical model of ISI (3)K2
- 9 Plot BER against SNR for a BPSK system (3)K2
- 10 Draw the signal constellation of a QPSK system with and without AWGN. (3)K3

PART B

Answer one question from each module. Each question carries 14 mark.

Module I

- 11(A) Give the model of AM signal and plot its spectrum (10)K2
 11(B) If a sinusoidal is amplitude modulated by the carrier (4)K3
 $5 \cos 2\pi 300t$ to a depth of 30 %, compute the power in the resultant AM signal.

OR

- 12(A) Explain how SSB is transmitted and received. (10)K2
 12(B) Compute the bandwidth of the narrow band FM signal with (4)K3
 modulating signal frequency of 1kHz and index of modulation 0.3

Module II

- 13(A) Compute the entropy of Gaussian random variable. (10)K3
 13(B) Give the relation between autocorrelation and power (4)K2
 spectral density of a WSS.

OR

- 14(A) Test whether the random process $X(t) = A \cos 2\pi ft + \theta$ is (10)K3
 WSS if θ is uniformly distributed in the interval $[-\pi, \pi]$
 14(B) Explain mutual information. Give its relation with self in- (4)K2
 formation.

Module III

- 15(A) A WSS process with autocorrelation $R_X(\tau) = e^{-\alpha|\tau|}$ is (10)K3
 applied to an LTI system with impulse response $h(t) = e^{-\beta t}$ with $|\alpha| > 0$ and $|\beta| > 0$. Find the output power spectral density
 15(B) Give the conditions for stationarity in the strict sense. (4)K2

OR

- 16(A) Find an orthonormal basis set for the set of signals (7)K3

$$s_1(t) = A \sin(2\pi f_0 t); \quad 0 \leq t \leq T$$

and

$$s_2(t) = A \cos(2\pi f_0 t); \quad 0 \leq t \leq T$$

where $f_0 = \frac{m}{T}$ where m is an integer.

- 16(B) Plot the above signal constellation and draw the decision region on it. Compute the probability of error. (7)K3

Module IV

- 17(A) Compute the probability of error for maximum likely hood detection of binary transmission. (8)K3
- 17(B) Explain the term matched filter. Plot the BER-SNR curve for a matched filter receiver (6)K2

OR

- 18(A) Design a zero forcing equalizer for the channel that is characterized by the filter taps $\{1, 0.7, 0.3\}$ (8)K3
- 18(B) Explain partial response signaling (6)K2

Module V

- 19 For a shift keying system defined by $s(t) = A_c k \sin(2\pi f_c t) \pm A_c k \cos(2\pi f_c t)$ plot the signal constellation. Compute the probability of error. (14)K3

OR

- 20(A) Derive the probability of error for a QPSK system with Gray coding. (10)K3
- 20(B) Draw the BER-SNR plot for a QPSK system (4)K3

ECT 305 Analog and Digital Communication Simulation Assignments

The following simulation assignments can be done with Python/MATLAB/SCILAB/LabVIEW The following simulations can be done in MATLAB, Python, R or LabVIEW.

1 A-Law and μ -Law Characteristics

- Create a vector with say 1000 points that spans from -1 to 1 .
- Apply A-Law companding on this vector get another vector. Plot it against the first vector for different A values and appreciate the transfer characteristics.
- Repeat the above steps for μ -law as well.

2 Practical A-Law compander

- Implement the 8-bit practical A-law coder and decoder in Appendix B 2 (pp 583–585) in *Digital Telephony by Bellamy*
- Test it with random numbers and speech signals. Observe the 15 levels of quantization.

3 Practical μ -Law compander

- Implement the 8-bit practical μ -law coder and decoder in Appendix B 1 (pp 579–581) in *Digital Telephony by Bellamy*
- Test it with random numbers and speech signals. Observe the 15 levels of quantization.

4 BPSK Transmitter and Receiver

- Create a random binary sequence of 5000 bit. Convert it into a bipolar NRZ code.
- Create a BPSK mapper that maps bit 0 to zero phase and bit 1 to π phase.
- Plot the real part of the mapped signal against the imaginary part to observe the signal constellation
- Add AWGN of different variances to the base band BPSK signal and observe the changes in constellation.
- Realize the BPSK transmitter and receiver in Fig. 6.4 in page 352 in

Communication Systems by Simon Haykin .

- Add AWGN of different variances and compute the bit error rate (BER) for different SNR values.
- Plot the BER Vs. SNR.
- Plot the theoretical BER-SNR curve, using Eq. 6.19 in page 351 in *Communication Systems by Simon Haykin .*

5 QPSK Transmitter and Receiver

- Create a random binary sequence of 5000 bit. Convert it into a bipolar NRZ code.
- Create a QPSK mapper that maps bit patterns 00, 10, 11 and 01 to suitable phase values that are odd multiples of $\frac{\pi}{4}$
- Plot the real part of the mapped signal against the imaginary part to observe the signal constellation
- Add AWGN of different variances to the base band QPSK signal and observe the changes in constellation.
- Realize the QPSK transmitter and receiver in Fig. 6.8 in page 359 in *Communication Systems by Simon Haykin .*
- Add AWGN of different variances and compute the bit error rate (BER) for different SNR values.
- Plot the BER Vs. SNR.
- Plot the theoretical BER-SNR curve, using Eq. 6.33 in page 358 in *Communication Systems by Simon Haykin .*

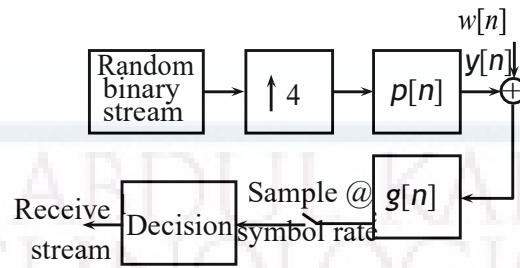
6 Matched Filter Receiver

The task is to develop a matched filter receiver, with zero ISI, as shown in the figure below.

- Generate 5000 random bits and up sample the stream by 4.
- For zero ISI, the impulse response of the transmitter and receiver filters are the RRC pulse with $\alpha = 0.2$.

$$p(t) = g(t) = \left(\frac{4\alpha}{\pi\sqrt{T}}\right) \left[\frac{\cos(1+\alpha)\frac{\pi t}{T} + \frac{T}{4\alpha t} \sin(1-\alpha)\frac{\pi t}{T}}{1 - \left(\frac{4\alpha t}{T}\right)^2} \right] \quad (1)$$

- Plot $p(t)$ and its approximate spectrum and appreciate.



- Add AWGN ($w[n]$) of different variances and compute the BER-SNR curve for the bit patterns received.

